WEEKLY REPORT- 07 Dec 2023 (Sindhuja Chaduvula)

This scenario features two vehicle types: 'default' and 'ego_vehicle', each with distinct characteristics like speed and acceleration. The file outlines four traffic flows for default vehicles, and a unique 'ego_car' set to depart at a specific simulation time, hinting at its central role in the study. This setup focuses on the interaction between regular traffic and the 'ego_vehicle' in a roundabout, offering insights into varied driving behaviors within a simulated urban environment for a roundabout.

Attributes of 'default' and 'ego_vehicle' types used in the simulation

Attribute	Default Vehicle	Ego Vehicle	Description
ID	default	ego_vehicle	Unique identifier for the vehicle type.
Max Speed (maxspeed)	25	60	The maximum speed the vehicle can achieve.
Acceleration (accel)	1.5	11.0	The rate at which the vehicle can increase its speed.
Deceleration (decel)	3.0	13.0	The rate at which the vehicle can decrease its speed.
Emergency Decel (emergencyDecel)	4.0	14.0	The rate of deceleration in emergency situations.
Minimum Gap (minGap)	2.5	1.0	The minimum distance to maintain from the vehicle in front.
Minimum Gap Factor (collisionMinGapFactor)	0.3	0.3	Factor for minimum gap to avoid collisions.
Time Headway (tau)	1.5	0.4	The desired time gap between the vehicle and its leader.
Color	0.5, 0.5, 0.5 (Gray)	1.0, 0.0, 0.0 (Red)	The color representation of the vehicle in the simulation.
Lane Change Model	-	LC2013	The model used for simulating lane changes.
Impatience	0.2	1.0	The degree of urgency a driver shows in congested conditions.
Car Following Model	EIDM	EIDM	The model used for simulating car-following behavior.

Other parameters that further define the vehicles' driving behaviors and their interactions in the simulation include:

Parameter	Default Vehicle	Ego Vehicle	Description
Lane Change Model (lcStrategic, lcCooperative, etc.)	lcStrategic: 0.5, lcCooperative: 5.0	lcAssertive: 50, lcStrategic: 5.0, lcCooperative: 0.1, lcSpeedgain: 10.0, lcPushy: 10, lcImpatience: 10	Parameters controlling the behavior during lane changes.
Junction Model (jmSigmaMinor, jmIgnoreFoeSpeed, etc.)	jmSigmaMinor: 1, jmIgnoreFoeSpeed: 10, jmTimegapMinor: 1.0, jmIgnoreJunctionFoeProb: 1, jmIgnoreKeepClearTime: 1	jmIgnoreFoeProb: 1.0	Parameters defining behavior at junctions.
Gap Parameters (sigmagap, sigmaerror)	sigmagap: 0.4, sigmaerror: 0.3	sigmagap: 0.9, sigmaerror: 0.9	Parameters influencing the variation in

Parameter	Default Vehicle	Ego Vehicle	Description
			maintaining gaps and errors.

Simulation

The simulation is performed with the following parameters being used:
--random: This makes the simulation use random seed values. It ensures that each simulation run is different from the others, which is useful for observing varied outcomes.
--collision.action remove: This defines the action to take when a collision occurs. In this case, remove means that vehicles involved in collisions will be removed from the simulation.
--max-num-vehicles 60: This sets the maximum number of vehicles that can be present in the simulation at any time to 60.
--step-length 0.1: This sets the duration of each simulation step to 0.1 seconds. Shorter step lengths can result in more detailed simulations.

Output generated from the simulation include:
--collision-output: This file contains the details of any collisions during the simulation.
--fcd-output: The file includes detailed information about each vehicle's position and speed at each time step.

Data Preparation

The data generated from the simulation is then further processed to prepare it for training the model

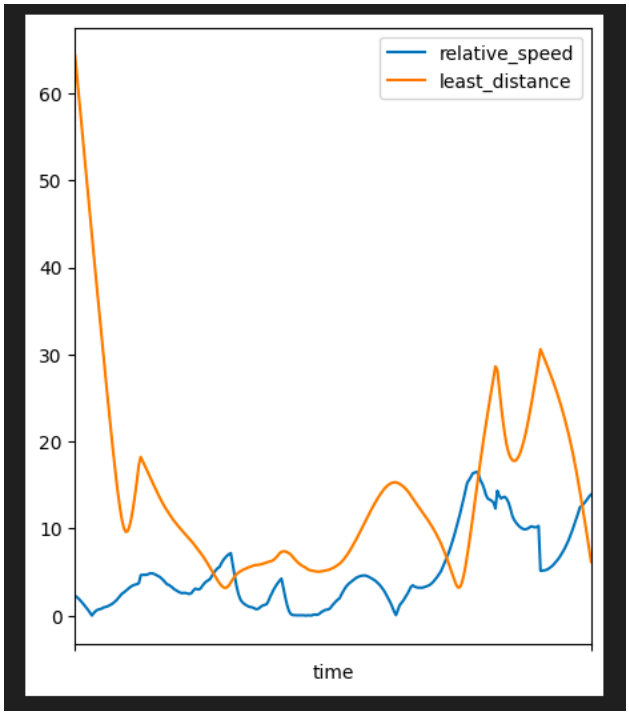
- **XML Data Parsing**: The Full-Car-Detector (FCD) data for the ego vehicle and all vehicles, and collision data are extracted from XML files
- **Data Merging**: The FCD data for the ego vehicle is merged with collision data.
- **Feature Engineering**: Additional features are calculated for the vehicles. These features include:
    - Acceleration: For each vehicle, its acceleration is computed.
    - Nearest Vehicle ID and Distance: For each vehicle at each time step, the nearest vehicle is found by calculating the distance to all other vehicles. Also, the distance to the nearest vehicles is used as a feature.
    - Relative Speed: The absolute difference in speed between the vehicle and its nearest vehicle.

The enriched FCD data with these additional features is saved with the data for the ego vehicle being isolated. This data of the ego vehicle will be used for training our model.

5 simulation runs have been executed and the data is prepared as stated above for each of the run.

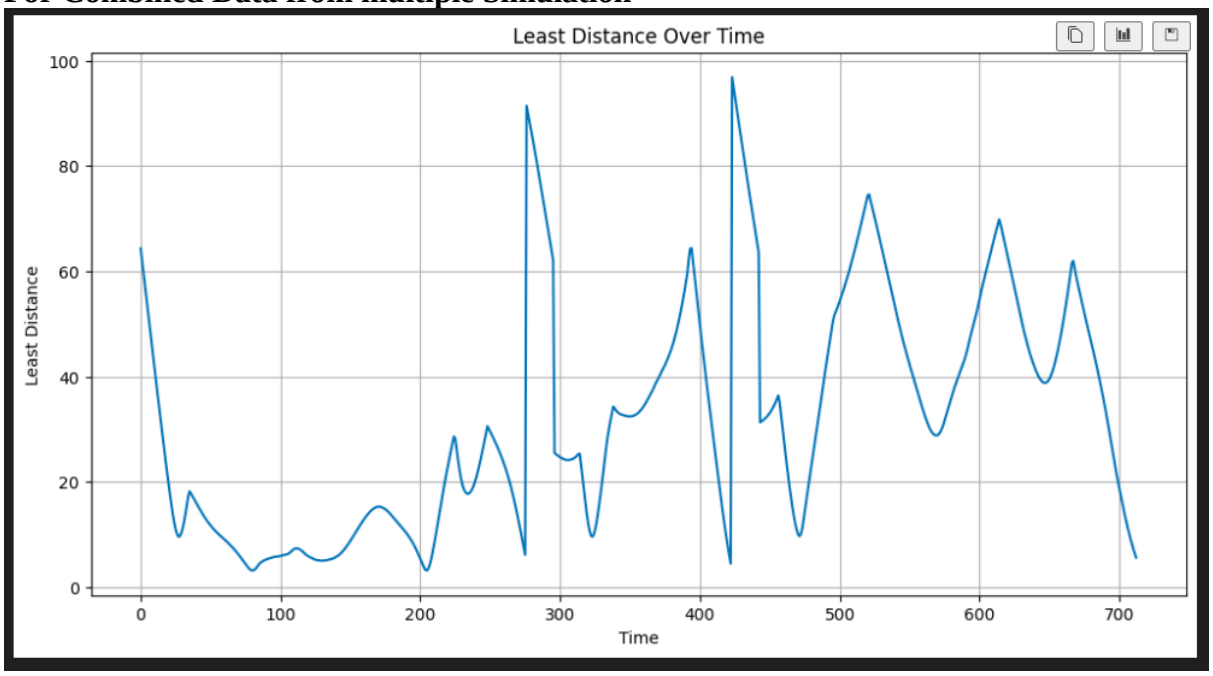
Data Exploration –

For Single Simulation



The graph depicts the relationship between **relative_speed** and **least_distance** over time, with **relative_speed** generally showing less variation compared to **least_distance**, which exhibits sharper fluctuations. These metrics might suggest interactions between the ego vehicle and other traffic participants, with relative speed changes possibly reflecting acceleration or deceleration, and distance spikes potentially indicating overtaking or varied traffic density.

For Combined Data from multiple Simulation



The distance values vary significantly, at times reaching above 80 units, and at other times dropping below 20 units. This could represent the changing distances between objects (like vehicles in a traffic simulation) over the course of time, with the spikes possibly indicating instances when the distance sharply increases or decreases. The overall pattern is irregular, suggesting that the movement of these objects is not steady but rather varies dynamically.

Model Training

The experiment is performed by training two models – LSTM and GRU. LSTM (Long Short-Term Memory) and GRU (Gated Recurrent Unit) are both advanced types of Recurrent Neural Networks used to analyze sequential data. LSTMs are complex and can capture long-term dependencies with their memory cells and three gates (input, forget, and output). GRUs are simpler, combining two of these gates into one and generally compute faster.

For each model, two types of training are performed. First by using the simulation data of single simulation and secondly by combining the simulation data from 5 runs.

1. LSTM Model Trained with Single Simulation

Here, LSTM model is trained using the data processed from a single simulation.
Timestep used for the model – 3
No. of epochs – 50
Training Accuracy achieved – 72.39%

Results obtained after training the model –

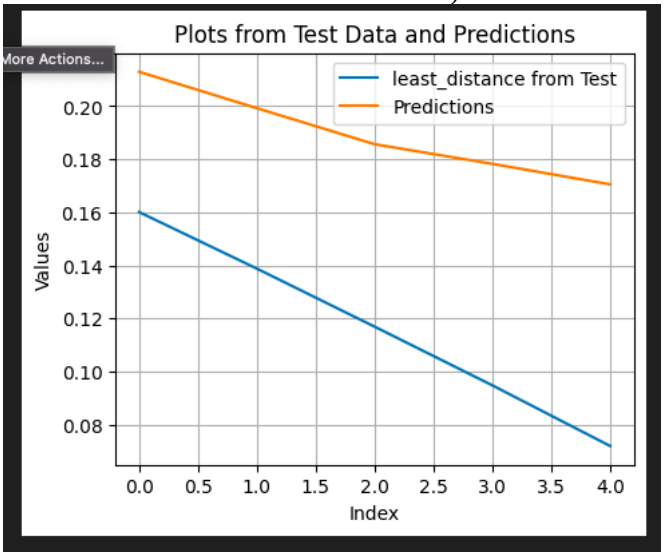
Predicted Values

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.702930	0.653463	0.432978	0.363213	0.586639	-0.396997	0.542426	0.212978	0.583684
0.690679	0.632460	0.426070	0.342752	0.614216	-0.399794	0.543815	0.199259	0.593025
0.675644	0.615448	0.420481	0.324365	0.636118	-0.401946	0.540769	0.185678	0.596268
0.680210	0.618499	0.432038	0.320793	0.652210	-0.409620	0.547064	0.178280	0.603777
0.685090	0.621430	0.443946	0.317016	0.668998	-0.417540	0.553557	0.170550	0.611789

Actual Values

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.843478	0.964843	0.254857	0.067128	0.477051	0.0	0.527094	0.160122	0.763923
0.849391	0.972104	0.270679	0.053687	0.494845	0.0	0.541872	0.138807	0.777240
0.856348	0.979294	0.287202	0.041566	0.512851	0.0	0.556650	0.116925	0.792373
0.864348	0.986340	0.304426	0.028358	0.530998	0.0	0.571429	0.094807	0.810533
0.873391	0.993278	0.322451	0.013830	0.549287	0.0	0.586207	0.071958	0.829298

Comparison of least_distance feature value predicted by the algorithm with the actual value -
(least_distance is an essential feature for the collision of the vehicle)



The graph presents a comparison between actual test data for 'least_distance' and its corresponding predictions, over a sequential index. The 'least_distance' from the test data shows a declining trend, while the predictions remain relatively constant across the index, indicating a variance between the expected values and the model's predictions.

2. GRU Model Trained with Single Simulation

Here, GRU model is trained using the data processed from a single simulation.
Timestep used for the model – 3
No. of epochs – 50
Training Accuracy achieved – 91.4%

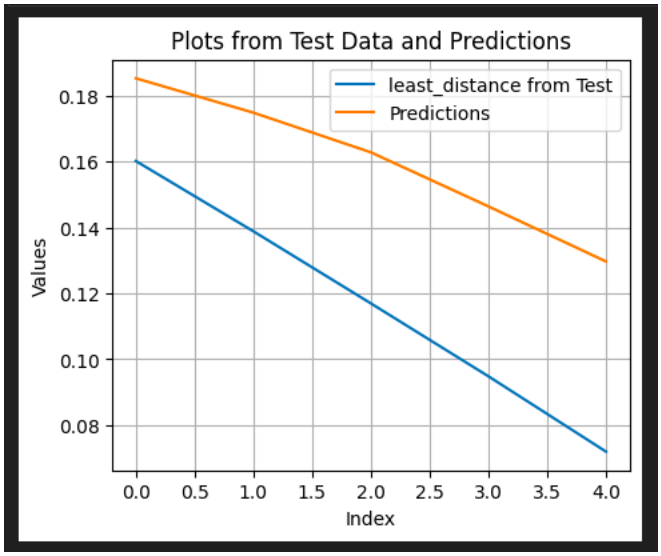
Results obtained after training the model –

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.779137	0.893916	0.178619	0.071752	0.497058	0.006797	0.609331	0.185218	0.722331
0.763238	0.889983	0.186828	0.060240	0.506794	0.007661	0.550779	0.174793	0.750692
0.751690	0.883211	0.202545	0.053818	0.518782	0.008274	0.526254	0.162754	0.770641
0.755202	0.886410	0.214159	0.042099	0.539742	0.008504	0.535303	0.146348	0.785535
0.759088	0.889242	0.226237	0.029584	0.561114	0.008696	0.543900	0.129644	0.801962

Actual Values -

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.843478	0.964843	0.254857	0.067128	0.477051	0.0	0.527094	0.160122	0.763923
0.849391	0.972104	0.270679	0.053687	0.494845	0.0	0.541872	0.138807	0.777240
0.856348	0.979294	0.287202	0.041566	0.512851	0.0	0.556650	0.116925	0.792373
0.864348	0.986340	0.304426	0.028358	0.530998	0.0	0.571429	0.094807	0.810533
0.873391	0.993278	0.322451	0.013830	0.549287	0.0	0.586207	0.071958	0.829298

Comparison of least_distance feature value predicted by the algorithm with the actual value -
(least_distance is an essential feature for the collision of the vehicle)



The graph shows two lines, one for actual test data and another for model predictions, both trending downward as the index increases. The actual test data declines more steeply than the predictions, indicating some discrepancy between the model's output and the real-world values. It can also be observed that the prediction from GRU has lower discrepancy than the LSTM.

3. LSTM Model Trained with Combined data

Here, LSTM model is trained using the data processed from multiple simulations.
Timestep used for the model – 3
No. of epochs – 50
Training Accuracy achieved – 78.87%

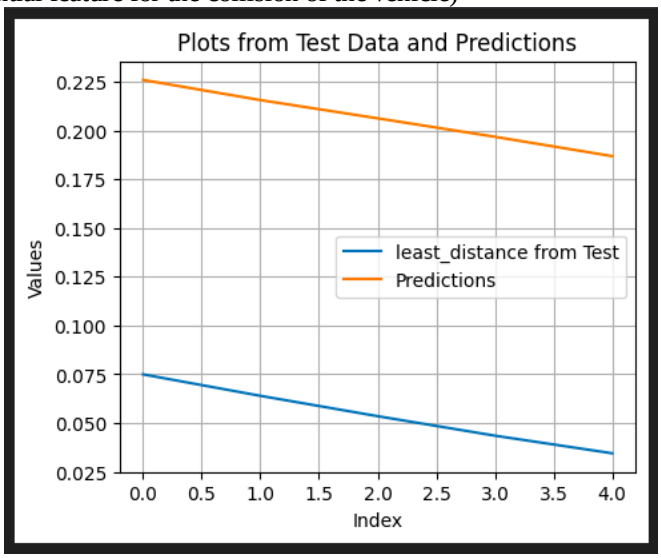
Results obtained after training the model –

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.565579	0.649295	0.756583	0.212885	0.652565	-0.258827	0.370033	0.225907	0.473060
0.557338	0.648596	0.778943	0.212128	0.654336	-0.261008	0.377050	0.215589	0.462164
0.542323	0.639649	0.790013	0.209869	0.652825	-0.254797	0.367995	0.206225	0.450688
0.529031	0.635240	0.803498	0.212903	0.653065	-0.253359	0.372323	0.196760	0.434802
0.511719	0.623817	0.808980	0.212928	0.648320	-0.244292	0.357723	0.186839	0.421049

Actual Values -

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.474460	0.997766	0.783805	0.022757	0.901087	0.0	0.216	0.074971	0.412315
0.454919	0.998366	0.797618	0.017660	0.910630	0.0	0.332	0.063972	0.395557
0.432636	0.998900	0.810730	0.012564	0.919685	0.0	0.300	0.053529	0.375682
0.408639	0.999333	0.823241	0.008178	0.928253	0.0	0.280	0.043532	0.355027
0.380528	0.999700	0.834851	0.003615	0.936264	0.0	0.232	0.034505	0.328137

Comparison of least_distance feature value predicted by the algorithm with the actual value - (least_distance is an essential feature for the collision of the vehicle)



The 'least_distance from Test' line is decreasing, suggesting that the actual test measurements of distance decrease as the index (or time) progresses. In contrast, the 'Predictions' line is relatively flat, indicating that the model's predictions do not vary much with the index and do not follow the same downward trend as the actual test data. This suggests a discrepancy between the model's predictions and the actual test data.

3. GRU Model Trained with Combined data

Here, GRU model is trained using the data processed from multiple simulations.
Timestep used for the model – 3
No. of epochs – 50
Training Accuracy achieved – 89.67%

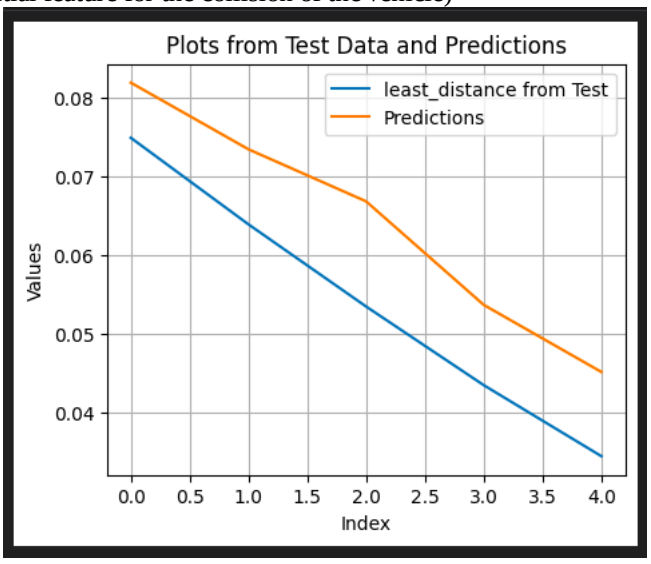
Results obtained after training the model –

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.443550	0.932248	0.794480	0.052147	0.855350	-0.007410	0.291738	0.081972	0.408909
0.428637	0.935014	0.814082	0.057505	0.857098	-0.004652	0.333468	0.073507	0.387266
0.409044	0.936298	0.823402	0.049293	0.865546	-0.005829	0.329091	0.066890	0.370741
0.384782	0.933959	0.832731	0.043250	0.874527	-0.007070	0.317885	0.053732	0.353804
0.357394	0.932529	0.839690	0.038598	0.881301	-0.008300	0.288195	0.045209	0.330457

Actual Values -

Speed	X	Y	Angle	Pos	Slope	Acceleration	Least Distance	Relative Speed
0.474460	0.997766	0.783805	0.022757	0.901087	0.0	0.216	0.074971	0.412315
0.454919	0.998366	0.797618	0.017660	0.910630	0.0	0.332	0.063972	0.395557
0.432636	0.998900	0.810730	0.012564	0.919685	0.0	0.300	0.053529	0.375682
0.408639	0.999333	0.823241	0.008178	0.928253	0.0	0.280	0.043532	0.355027
0.380528	0.999700	0.834851	0.003615	0.936264	0.0	0.232	0.034505	0.328137

Comparison of least_distance feature value predicted by the algorithm with the actual value - (least_distance is an essential feature for the collision of the vehicle)



Both lines exhibit a downward trend indicating decreasing values over the index. The 'least_distance from Test' line starts higher and decreases more rapidly than the 'Predictions' line, which suggests that the predictions do not decrease as quickly as the actual test data. The predictions in this case are more closer than the LSTM model.